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(54) Title: FLEXIBLE, FEATURE-BASED SYSTEM SELECTION PROTOCOL

Priority	Example 1	Example 2
1	Home PLMN	Home PLMN
2	Last PLMN	Home SID
3	Preferred PLMN	Last PLMN
4	Other PLMN	Preferred PLMN
5	Home SID	Positive SID
6	Positive SID	Other PLMN
7	Other SID	Other SID

(57) Abstract: A multi-protocol system selection capability for a mobile station that provides prioritization based on system features as well as on system identification. The inter-protocol and intra-protocol background scanning functionality, as currently specified for GAIT Phase 1, is preferably incorporated, although other scanning techniques could be used as well. In general, a variable number of priorities are allowed, with configurable scanning behavior for each priority, as well as a configurable treatment for each priority. In addition, the multi-protocol system selection capability allows seamless prioritization between different protocols, and furthermore provides a high level of flexibility to allow for divergent and evolving operator preferences and requirements. This is accomplished by simply modifying a mobile station database, as opposed to revising the system selection algorithm software.

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FLEXIBLE, FEATURE-BASED SYSTEM SELECTION PROTOCOL

CLAIM OF PRIORITY FROM A COPENDING PROVISIONAL PATENT APPLICATION:

Priority is herewith claimed under 35 U.S.C. §119(e) from copending Provisional Patent Application 60/171,352, filed 12/22/99, entitled "Flexible Multi-Protocol System Selection Based on System Identification Parameters", by Kenneth McClure. Priority is also herewith claimed under 35 U.S.C. §119(e) from copending Provisional Patent Application 60/171,370 filed 12/22/99, entitled "Feature Based System Selection Priority Modification", by Kenneth McClure. The disclosure of these Provisional Patent Applications are incorporated by reference herein in their entireties.

FIELD OF THE INVENTION:

This invention relates generally to wireless telecommunication networks wherein multiple wireless systems or service providers are capable of servicing a particular mobile terminal or mobile station, and pertains more specifically to methods and apparatus for the mobile station to select a particular wireless service provider from which service is to be obtained.

BACKGROUND OF THE INVENTION:

The specification of system selection protocols has been an ongoing effort for a number of years in the wireless telecommunications field, in particular in the cellular telephone area. For example, in the AMPS system the mobile station is given a choice between possible serving systems based on the system identification (SID) parameter, wherein in one technique the mobile station is enabled to identify and select its Home system when it is encountered. Another technique involves setting a certain frequency band preference to control the band scanning process. For example, possible band preferences may be: scan only the A band, scan only the B band, scan only the band containing the Home SID (A or B), or a standard technique, where the Home band is scanned first, followed by the other band.

A further development provided positive/negative SID lists, where the positive SID list contains SID information for desirable non-Home systems, while the negative SID list contains SID information for those systems that are to be used only in the event an emergency call needs to be originated by the mobile station. This technique can be used in conjunction with the Home SID/band preferences discussed above to provide a desired band scanning order with restrictions.

Another development is referred to as Intelligent Roaming, which is an expansion of the positive/negative SID list technique. In the Intelligent Roaming approach various mechanisms are provided to: use a broadcast System Operator Code (SOC) as well as the SID to prioritize systems; provide for three different priorities (in addition to Home and Unidentified); for prioritizing the 800 MHz and 1900 MHz bands for scanning; for transitioning to a more preferred system when camped on a less preferred system; and for controlling the display of system identification text (using the so-called alpha-tags).

When using the broadcast SOC and the SID the mobile station maintains one list for each, and configurable arbitration is used to control selection when the SID and SOC have different priorities.

One benefit to using the SOC is a reduction in database size, as the SOC(s) for a particular operator do not change between different areas (like the SID). As such, one SOC entry in the mobile station database can encompass all systems belonging to a specific operator, which could require a prohibitive number of SID entries to achieve the same result. When combined with the area-specific system designation of the SID, this technique provides a means to assign a general priority for a particular operator (based on the SOC), while also providing area-specific exceptions (based on the SID).

Intelligent Roaming provides five different system classes or priorities which, in descending priority order are: Home (SID or SOC); Partner; Favored; Neutral (designated by a failure to match SID parameters in the mobile station's database; and Forbidden (utilized only to make emergency calls). The Partner priority provides a method to set multiple SID and SOC entries in the database with an equivalent priority with the HOME SID and SOC. The Favored priority provides a method for having two preferred systems in the same area with one, the Favored system, serving as a less desirable backup for the other (the Home or Partner system).

Intelligent Roaming also provides a band order list to provide combined prioritization of the 800MHz and 1900MHz bands. Each band is assigned a unique rank to designate the order in which the bands are scanned. Furthermore, one or more bands can be designated as barred.

The band ranking provides several benefits, one being that the elimination of one or bands from the background scanning process improves the overall scanning efficiency. Another benefit is that the band ranking provides a means to differentiate between

systems having the same priority (when scanning). That is, the band ranking technique provides a tiebreaking mechanism for equal priority systems.

In addition to providing background scanning control, Intelligent Roaming provides a process for transitioning to a higher priority system when camped on a lower priority system. This process may be referred to as a "triggered scan". In this technique the mobile station periodically evaluates other systems while maintaining service on the current system. Triggered scans can be performed when the mobile station is camped on a neutral system and, optionally, when camped on a Favored system. There are two types of triggered scans: a partial scan (one band) and a wide-band scan (multiple bands). The band evaluated by the partial scan is determined using a combination of a record of historical band utilization and the band order list. If either the partial scan or the wide-band scan reveals a higher priority system than the current serving system, then the mobile station abandons the current serving system in favor of the higher priority system.

The Intelligent Roaming technique can also provide a means of displaying a priority-determined alpha-tag to the user of the mobile station. In general, a different alpha-tag is stored for each priority, and the operator can configure which alpha-tag is to be displayed when the mobile station receives a broadcast alpha-tag.

There are several multi-protocol system selection issues that have been addressed in the prior art. A GSM North America (GSM NA) group has established a system selection technique for GSM 1900MHz and AMPS (800MHz). This approach incorporated the Positive/Negative SID list functionality with the standard GSM system selection protocol, and also included additional functionality. The GSM NA derived the system priorities based on the GSM Public Land Mobile Network (PLMN) identifier. The GSM prioritization categories are, in descending priority order: Home PLMN; Preferred PLMN; Other PLMN (unmatched in the mobile station's database); and Forbidden PLMN. The AMPS priorities are, in descending priority order: Home SID; Positive SID, Other SID (unmatched in the mobile station's database), and Negative SID. The systems identified in the Forbidden PLMN and the Negative SID can only be used to make emergency calls.

One feature of this approach is the configurable prioritization between protocols. That is, the priority level for each priority class may be set to favor one protocol differently than the other. Fig. 1 depicts two examples of possible priority arrangements for the GSM/AMPS system selection technique.

This technique also provides a method for the mobile station to search for a GSM system while idle on an AMPS system, at configurable intervals. In addition, the mobile station can be configured to scan in one of the following sequences: GSM first, followed by AMPS; GSM only; and AMPS only. Furthermore, the AMPS scanning sequence uses the same type of band preference setting as discussed above with regard to the band-based system selection technique.

Finally, a GAIT Phase 1 system selection technique provides a scheme that is capable of meeting the needs of system operators while minimizing the required implementation effort. One result of this effort has brought about a technique that incorporates Intelligent Roaming and standard GSM system selection, with certain added functionality for cross-protocol issues.

With regard to priority grouping, the system priorities are divided into three groups describing the treatment of systems. Referring to Fig. 2, these groups are derived from the defined mobile station behavior for each priority as defined in GSM and ANSI-136. These groups are defined as follows: Group A, utilize immediately without further scanning and, once camped, do not search for a better system; Group B, utilize only when no Group A system in present and, once camped, search for better system; and Group C, use only for emergency calls.

With regard to inter-protocol prioritization, the overall system prioritization is controlled by a protocol priority indicator. The protocol priority indicator can dictate the following mobile station behavior: ANSI-136/AMPS only, single protocol operation, system selection as specified by ANSI-136; GSM only, single protocol operation, system selection as specified in GSM; ANSI-136/AMPS preferred, multiple protocol operation following appropriate standard for system selection in respective protocols, with reference being made to Fig. 3 for inter-protocol priority ranking; GSM preferred, multiple protocol operation, following the appropriate standard for system selection in the respective protocols (refer again to Fig. 3); and ANSI-136/AMPS Persistent (Global Packet Radio System (GPRS) Only), multiple protocol operation that performs as ANSI-136/AMPS preferred with the exception that any acceptable (non-forbidden) ANSI-136/AMPS system is secured without requiring a GSM scan.

As denoted by the definition of the Group B priorities in Fig. 3, the system selection method provides a means to transition to a higher priority system in one protocol when

camped on a lower priority system in another protocol. This transitioning is accomplished by performing cross-protocol scans at intervals that are designated by the protocol in which the mobile station is camped. When the mobile station is camped on a Group B system in GSM, a Home Rescan timer determines the interval at which cross-protocol scanning occurs. When the mobile station is camped on a Group B system in ANSI-136, the cross-protocol scan is instead performed after the wide-band triggered scan.

While the above-described GAIT Phase 1 system selection technique provides an operational foundation for multi-protocol mobile stations, interest has grown in expanding the scope of the multi-protocol concept.

One area of multi-protocol expansion is in the Global GSM/ANSI-136 mobile station environment, wherein a mobile station is required to support the following: ANSI-136, GSM 900, GSM 1800 and GSM 1900. As can be appreciated, a mobile station that is to support these various protocols must avoid certain pitfalls, such as avoiding scanning for certain protocols or in certain bands when there is no chance of finding a useful system there. The scanning for absent bands/protocols is a poor utilization of time and battery power. For example, most areas having GSM 900/1800 systems will not have GSM 1900 or ANSI-136 systems.

Another area of growing interest relates to feature considerations for system selection (e.g., the availability of SMS, voice privacy, GPRS, etc.) However, it has not yet been determined how feature consideration will affect prioritization. For example, the feature availability of a system may need to supersede system priority, or it may simply need to differentiate systems of equal priority. Some combination of these two techniques may also be called for.

Furthermore, there is a need to prioritize systems based on roaming agreements between service providers, regardless of the protocol of the system. This type of prioritization allows the mobile station to take full advantage of cross-protocol roaming agreements that are beneficial to the system operator. Moreover, this type of seamless prioritization should include ANSI-136 Non-Public Systems.

Furthermore a general divergence of operator requirements is resulting in a divergence in system selection requirements, which can result in conflicts when attempting standardize a system selection algorithm, and which can then further result in an increased complexity of the algorithm. One example is the special function bit fields that have been

incorporated into the Intelligent Roaming algorithm. As such, it would be desirable to provide an ability to provide broad configurability without requiring multiple algorithms.

Also, as the system selection requirements evolve in the operator marketplace, a need has arisen to provide a system selection technique that is capable of adjusting to minor changes in requirements without any algorithm changes, and that is further capable of adjusting to major changes in requirements with only minor changes to the system selection algorithm.

OBJECTS AND ADVANTAGES OF THE INVENTION:

It is a first object and advantage of this invention to provide an improved multi-protocol system selection technique that overcomes the foregoing and other problems, and that addresses the needs that have arisen.

It is a further object and advantage of this invention to provide a multi-protocol system selection algorithm for a mobile station that provides prioritization based on system features as well as system identification.

It is another object and advantage of this invention to provide a network operator capable of downloading a multi-protocol system selection database to a mobile station that provides prioritization based on system features as well as system identification.

SUMMARY OF THE INVENTION

The foregoing and other problems are overcome and the objects of the invention are realized by methods and apparatus in accordance with embodiments of this invention.

The teachings herein provide a multi-protocol system selection capability for a mobile station that provides prioritization based on system features as well as system identification. The inter-protocol and intra-protocol background scanning functionality, as currently specified for GAIT Phase 1, is preferably incorporated, although other scanning techniques could be used as well. In general, a variable number of priorities are permitted, with configurable scanning behavior for each priority, as well as a configurable treatment for each priority. In addition, the multi-protocol system selection capability allows seamless prioritization between different protocols, and furthermore provides a high level of flexibility to allow for divergent and evolving operator preferences and requirements. This is accomplished by simply modifying the mobile station database, as

opposed to revising the system selection algorithm software.

BRIEF DESCRIPTION OF THE DRAWINGS

The above set forth and other features of the invention are made more apparent in the ensuing Detailed Description of the Invention when read in conjunction with the attached Drawings, wherein:

Fig. 1 depicts two examples of possible priority arrangements for a prior art GSM/AMPS system selection technique;

Fig. 2 illustrates system priorities divided into three priority groups (A-C), with the mobile station behavior for each priority being defined in GSM and ANSI-136;

Fig. 3 depicts, for an ANSI-136/AMPS and a GSM preferred inter-protocol prioritization technique, a prior art inter-protocol priority ranking, wherein in Figs. 2 and 3 the Favored protocol can be configured to eliminate searching for a higher priority system once the mobile station camps on the Favored system;

Fig. 4 is a simplified block diagram showing a wireless telecommunications system that includes a mobile station as well as exemplary first and second network operators;

Fig. 5 is a diagram showing a general case of Prioritization Thresholds;

Fig. 6 is a diagram showing the Prioritization Thresholds of Fig. 5 applied to Intelligent Roaming;

Fig. 7 is a diagram showing a general case of Functionality and Prioritization Thresholds;

Fig. 8 is a diagram showing the Functionality and Prioritization Thresholds of Fig. 7 applied to Intelligent Roaming;

Fig. 9 is a diagram showing Attribute Supplements applied to Intelligent Roaming;

Fig. 10 is a diagram showing a Priority Group overlap resulting from an Attribute modification;

Fig. 11 is a diagram showing a variation in Priority Group Size to control the modification overlap;

Fig. 12 depicts a structure of a System Identification Parameter List;

Fig. 13 depicts a structure of a Special Parameter Setting;

Fig. 14 illustrates a list of eight areas and an associated system operator configuration, and is useful in explaining an example of the utility of the multi-protocol system selection algorithm in accordance with the teachings of this invention;

Fig. 15 depicts an exemplary System Identification Parameter List in accordance with the example depicted in Fig. 14;

Fig. 16 illustrates the resulting Special Parameter Settings in accordance with the example of Figs. 14 and 15; and

Fig. 17 illustrates an exemplary prioritization scheme.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 4, therein is illustrated a simplified block diagram of an embodiment of a wireless telecommunications system that includes a mobile station 10 that is suitable for practicing this invention. Fig. 4 also shows a first network operator (NO1), also referred to herein simply as a first system, that transmits in a forward or downlink direction both physical and logical channels to the mobile station 10 in accordance with a predetermined air interface standard or protocol. In the presently preferred, but not limiting, embodiment, the protocol could conform to one of the above-mentioned ANSI-136, AMPS, or various ones of the GSM protocols, and/or to various modifications and enhancements thereto. In a typical case a second (and third, fourth, etc.) network operator (e.g., NO2 or second system) may also be capable of transmitting to the mobile station 10 using the same or a different protocol as NO1, although at any given time the mobile station 10 will be connected to only one network operator. However, when camped on a control channel of NO1 or NO2 the mobile station 10 may be scanning for the other. Although not specifically shown in Fig. 4, it is assumed that a reverse or uplink communication path exists from the mobile station 10 to the network operator that conveys mobile station 10 originated access requests, a traffic channel and the like.

The mobile station 10 typically includes a micro-control unit (MCU) 12 having an output coupled to an input of a display 14 and an input coupled to an output of a keyboard or keypad 16. The mobile station 10 may be considered to be a radiotelephone, such as a cellular telephone or a personal communicator having voice an/or packet data capabilities, or it may be a wireless packet data terminal. The MCU 12 is assumed to

include or be coupled to a read-only memory (ROM) 12A for storing an operating program, as well as a random access memory (RAM) 12B for temporarily storing required data, scratchpad memory, etc. A portion of the RAM 12B may be non-volatile, enabling data to be retained when power is turned off. The non-volatile portion of the RAM 12B is assumed to store a multi-protocol system selection database (DB) 12C that is organized and managed in accordance with the teachings herein. A separate removable SIM 15 can be provided as well, the SIM storing, for example, subscriber-related information. In some embodiments of this invention it may be preferred to store the database 12C in the SIM 15. Regardless of where the multi-protocol system selection database 12C is stored, it is preferred to download the contents of the database 12C over the air from, for example, the Home network operator.

The ROM 12A is assumed, for the purposes of this invention, to store a program for executing the software routines required to achieve compatibility with the various protocols supported by the network operators NO1 and NO2, and also stores a multi-protocol system selection algorithm in accordance with the teachings herein.

The mobile station 10 also contains a wireless section that includes a digital signal processor (DSP) 18, or equivalent high speed processor, as well as a wireless transceiver comprised of a transmitter 20 and a receiver 22, both of which are coupled to an antenna 24 for communication with the currently selected network operator. Some type of local oscillator (LO) 19, which enables the transceiver to tune to different frequency channels when scanning and otherwise acquiring service, is controlled from the DSP 18.

One important aspect of the teachings of this invention is an ability to provide different types of configurable parameters or elements to control how the mobile station 10 compares the various systems one to another, and then reacts once encountering and/or utilizing a certain system. These configurable elements include the follow:

(A) Prioritization Thresholds define the general priority of the system based on the system identification.

(B) Functionality Thresholds dictate the manner in which the mobile station 10 behaves towards a particular system. This includes how the mobile station 10 behaves when encountering the system during scanning, as well as how the mobile station behaves when camped on the system.

(C) Attribute Supplements are used in conjunction with the Prioritization Thresholds to establish the specific priority of a system.

(D) Lists and supporting data fields provide a means for associating system broadcast parameters with the Thresholds in a usable manner.

These configurable elements will now be described in further detail.

Prioritization Thresholds

The prioritization threshold define a value to represent the general priority of a system based on system identification. The general priority establishes the basis of comparison of two or more systems, as well as a general relationship with respect to functionality thresholds. The threshold indicates the beginning (from the lowest level of desirability) of the priority group, as well as the end of the next lower priority group (if any).

As is illustrated in Fig. 5, there can be a variable number of priority groups, where there are **n** Prioritization Thresholds and **n** distinct priority groups. Each priority group is defined by its own Prioritization Threshold (the beginning of the group) and the next higher Prioritization Threshold (the end of the group).

Fig. 6 provides an example of the prioritization thresholds of Fig. 5, when applied to the case of Intelligent Roaming. To clarify the example, the Prioritization Thresholds are identified by the Intelligent Roaming priorities that they define. The Forbidden Threshold defines the beginning of the Forbidden priority group, the Neutral Threshold defines the beginning of the Neutral priority group and the end of the Forbidden priority group, the Favored Threshold defines the beginning of the Favored priority group and the end of the Neutral priority group, the Partner Threshold defines the beginning of the Partner priority group and the end of the Favored priority group, and the Home Threshold defines the beginning of the Home priority group and the end of the Partner priority group.

Functionality Thresholds

The functionality thresholds define the manner in which mobile station 10 reacts to a system (e.g., NO1 or NO2) of a certain priority when scanning, as well as when camped upon a system. The functional thresholds are as follows:

(A) A Usability Threshold defines the lowest allowed priority for use in non-emergency situations. Systems having priorities below this threshold can only be used for emergency

calls (e.g., 911 calls).

(B) A Background Scanning Prevention Threshold defines the lowest priority system that is exempt from performing background scanning. When the mobile station 10 is camped on a system having a priority below this threshold, it must perform background scanning (inter-protocol and intra-protocol).

(C) An Immediate Usage Threshold defines the lowest priority system that will be selected immediately upon being encountered by the mobile station 10. When the mobile station 10 encounters a system having this priority (or greater), the scanning process ends and the system is selected regardless of what other systems may be present.

As is seen in Fig. 7, the Functionality Thresholds can be set so that they fall anywhere within the prioritization spectrum. The Usability Threshold is set to directly coincide with the Priority **n-1** Threshold. Therefore, systems falling within priority group **n** can only be used to make emergency calls. The Background Scanning Prevention Threshold is set within priority group 2, and does not directly coincide with any particular prioritization threshold (explained in further detail below). Therefore, all priority 1 systems, and some priority 2 systems, are exempt from performing background scanning. The Immediate Usage Threshold is set to directly coincide with the priority 1 threshold and, as a result, the mobile station 10 will preempt scanning and immediately select a priority 1 system once encountered.

Fig. 8 is an example of the use of the Functionality Thresholds, again as applied to the case of Intelligent Roaming. To clarify the example, the Prioritization Thresholds are identified by the Intelligent Roaming priorities that they define. The Usability Threshold is set to coincide directly with the Neutral Prioritization Threshold. This setting ensures that forbidden systems are only used for emergency calls. However, Intelligent Roaming provides a Home Only Bit that restricts the mobile station 10 to utilizing only the Home system. Therefore, to provide this functionality the Usability Threshold is set to coincide directly with the Home Prioritization Threshold. The Background Scanning Prevention Threshold is set to coincide with the Partner Prioritization Threshold. This particular setting requires all systems having a lower priority than Partner to perform intermittent background scanning to locate a higher priority service. However, the Intelligent Roaming also provides a Triggered Scan Disable Bit that disables background scanning (triggered scanning) for the favored priority. Therefore, to comply with this setting the Background

Scanning Prevention Threshold is set to directly coincide with the Favored Prioritization Threshold. The Immediate Usage Threshold is set to directly coincide with the Partner Prioritization Threshold. This setting assures that the mobile station 10 will permit scanning and immediately select a Home or Partner system when encountered.

It should thus be appreciated that system operators may define and assign priority values, priority thresholds, as well as a number of priority classes as they desire.

It should be noted at this point that, in practice, a plurality of lists can be stored, for example Lists 1-3 containing wireless system descriptor information such as SOCs, and Lists 3-6 also containing wireless system descriptor information such as SIDs. Assume that List 1 contains all Partner SOCs and is assigned the highest priority (e.g., 99). List 2 contains all Favored SOCs and is assigned a lower priority (e.g., 70). List 3 contains all Forbidden SOCs and is assigned the lowest priority (e.g., -99). Assume further that List 4 contains all Partner SIDs and is assigned the same priority as the Partner SOCs (e.g., 99), that List 5 contains all Favored SIDs and is assigned the same priority as the Favored SOCs (e.g., 70), and that List 6 contains all Forbidden SIDs and is assigned the same lowest priority as the Forbidden SOCs (e.g., -99).

The priority for unmatched SOCs (Neutral SOCs) is set to be less than the priority for favored SOCs, but greater than the priority for Forbidden SOCs (e.g., 50). The priority for unmatched SIDs (Neutral SIDs) is set to be the same as that for the unmatched SOCs (e.g., 50). Finally, the Home SID and SOC are assigned the highest priority (e.g., 99).

In this case the lowest priority for Immediate Use would be set to be higher than Favored, but lower than or equal to Partner (e.g. 75). Also in this case the lowest priority for Any Use would be set to be higher than Forbidden, but lower than or equal to Neutral (e.g. 0).

In that the mobile station 10 should perform background scanning only on Favored and Neutral Systems, the priority range for background scanning preferably has an upper limit that is lower than the priority for immediate use (e.g., 74).

In this case if the operator desires to use a system selection method based on Intelligent Roaming, but with two additional priorities, these new priorities can be added with no software changes to the system selection algorithm stored in the ROM 12A of the mobile station 10. This can be achieved by downloading to the mobile station's database 12C four additional Lists, i.e.; List 7 and List 8 which respectively contain SIDs and SOCs

belonging to new priority 1, and List 9 and List 10 which respectively contain SIDs and SOCs belonging to new priority 2.

The priority levels for these new priorities are set according to the desired behavior. Assuming new priority 1 should not be immediately selected, should perform no background scanning, and have a priority between Favored and Partner, new priority 1 can be set to a value between Favored and Partner (e.g., 72). Furthermore, assuming new priority 2 should not be immediately selected, should perform background scanning, and have a priority between Forbidden and Neutral, new priority 2 can be set to a value between the lowest priority for use and the unmatched priority (e.g., 20).

Furthermore, GSM systems can be contained in the database 12C, thereby allowing GSM systems to be fully compatible and have configurable priority within the same prioritization framework as, for example, ANSI-136 systems.

Attribute Supplements

The Attribute Supplements provide a means to establish a system's prioritization based on qualities other than the system identity, and thus extend the teachings provided above. The Attribute Supplement is preferably implemented as a list of attributes with corresponding prioritization modification values. Once the attributes of a system (e.g., SMS support, GPRS support, etc) are determined, the attribute modification values are summed and applied to the Prioritization Threshold. This provides the specific priority of the system.

An example of this principle can be illustrated using an aspect of Intelligent Roaming. specifically the usage of the Band Order List to differentiate among systems having the same priority when performing scanning (not triggered scanning). In other words, systems of the same priority are sub-prioritized by the band in which they reside, which is ranked by a configurable band hierarchy. This sub-prioritization is illustrated in Fig. 9 (the Favored priority is used as an example). The bands illustrated in Fig. 9 are ranked from Band 7 to Band 1, with Band 1 having the highest priority. It can be seen that each successively ranked band has a higher modifier and, as a result, the specific system priority is unique.

The Attribute Supplement's modification range can be divided into two major categories. The first category involves modifications that distinguish between systems belonging to

the same priority group. This category is demonstrated in the Intelligent Roaming example (Fig. 9). The highest possible modification sum still places specific priority within the system's original priority group. The second category involves modifications that cause the system to change priority groups based on the Attribute Supplements. This second category is demonstrated in Fig. 10. When all three of the attribute modifiers are added to the Prioritization Threshold, the specific priority of the system may actually fall within a different priority group (i.e., it surpasses the next Prioritization Threshold).

It is possible to apply both of these modification range categories to a prioritization scheme by assigning the Prioritization Thresholds so that the priority groups are of different sizes. This priority group size variation is demonstrated in Fig. 11.

As an example, a user may desire data service and have the database 12C set up to modify priorities to enhance the probability of locating a system that supports data (e.g., a GPRS feature may be assigned a modifier of +1). Therefore, when the mobile station 10 locates a Neutral system with GPRS it will be treated as a Favored system, and when the mobile station 10 locates a Favored system with GPRS it will be treated as a Partner/Home system. Precautions are taken to insure that a Forbidden system is not upgraded in this manner.

In that the system priority levels can have gaps between them, different capabilities can affect priorities differently without surpassing another system's priority level, as well as cross-system priority levels.

As an example, assume a System Priority 1 is given a priority value of 80, and further assume a System Priority 2 is given a priority value of 50. If it is further assumed that a GPRS feature is given a priority modifier value of +4, and a circuit switched data feature is given a priority modifier value of +2, then the effective system ranking will be as follows: Priority 1 system (80); Priority 2 system with GPRS and circuit switched data (56); Priority 2 system with GPRS (54); Priority 2 system with circuit switched data (52); followed by Priority 2 system with no matched features (i.e., neither GPRS or circuit switched data).

As a further example, assume the System Priority 1 is again given a priority value of 80, but assume the System Priority 2 is given a priority value of 70. If it is further assumed that the GPRS feature is instead given a priority modifier value of +7, and the circuit switched data feature is given a priority modifier value of +4, then the effective system ranking will be as follows: Priority 2 system with GPRS and circuit switched data (81);

Priority 1 system (80); Priority 2 system with GPRS (77); Priority 2 system with circuit switched data (74); followed by a Priority 2 system with no matched features. That is, if the mobile station 10 locates a Priority 2 system with both features matched, the Priority 2 system will rank higher than the Priority 1 system with no matched features, and will be selected.

Lists and Supporting Data Fields

This section describes the system identification parameter lists that connect the Prioritization Thresholds with the actual wireless environment within which the mobile station 10 operates. Furthermore, this section contains descriptions of the supporting data fields that provide the multi-protocol system selection algorithm with robustness.

The System Identification Parameter Lists define the group of parameters that share common properties (Prioritization Threshold, Precedence, and Parameter Type). There may be a variable number of these lists within the system selection database 12C. The structure of each of these lists is illustrated in Fig. 12. The list can be subdivided into four major parts:

(A) The Prioritization Threshold is a priority value that is assigned (prior to modification) to a system that is identified by a parameter in the Parameter List.

(B) The Precedence a unique value used to determine a systems "true" Prioritization Threshold when there are multiple parameters defining the system (for example a SID and several SOCs, all having Prioritization Thresholds). In general, the Precedence field determines which parameter is dominant in systems with multiple identifiers.

(C) The Parameter Type provides the definition of the parameters contained within the Parameter List. For example, SID, SOC, or PLMN.

(D) The Parameter List is a list of all of the parameters that share the three properties above.

In the presently preferred embodiment of these teachings, all parameters within a specific System Identification Parameter List must be the same type. Therefore, SIDs and SOCs can not reside within the same list. However, it is possible as was shown above to assign the same Prioritization Threshold to different System Identification Parameter Lists. This can be used to allow identical prioritization for different lists (or lists of different types).

The database 12C also contains Special Parameter Settings for special situations. These settings may be provided separately for each parameter type to be utilized when the mobile station 10 is not able to match a specific parameter with any of the parameters stored within the database 12C. These settings are comparable with the Neutral settings in Intelligent Roaming, and provide a configurable method to prioritize unmatched parameters in a way that is consistent with the matched parameter prioritization. Another use for the Special Parameter Settings is the Home system parameters. These settings correlate the Home system parameters stored outside the system selection database 12C with the prioritization technique defined herein. In addition, the Special Parameter Settings enable non-Public systems (ANSI-136) to be accommodated into the prioritization technique. As shown in Fig. 13, the Special Parameter Settings contain only the Prioritization Threshold and the Precedence.

Furthermore, a Protocol Utilization field defines the protocols that the mobile station 10 is allowed to utilize. This field can be set to allow all supported protocols or to explicitly forbid certain protocols.

Implementation Example

A non-limiting implementation example is now provided to illustrate how the teachings of this invention can be applied. Reference can be had to Fig.17 during the ensuing discussion.

It is assumed for this example that the first network operator NO1 (ANSI-136, referred to below as Operator A) has roaming agreements with the following operators listed in order of desirability: Operator B (GSM), Operator C (ANSI-136), Operator D (GSM), Operator E (ANSI-136). This listing indicates that Operator A would prefer to utilize operator B's system over operator C's system, and so on. It is further assumed that there exist areas (e.g., eight areas) with the operator configuration illustrated in Fig. 14.

It can also be assumed that there are other areas, but this example is just concerned with the eight areas listed in Fig. 14. Furthermore, it is assumed that Operator A and Operator B do not share the same area. In addition, Operator A does not wants its customers to utilize Operators F and G (GSM) or Operators H and I (ANSI-136).

To solve this dilemma, each desirable operator may be given its own Prioritization Threshold, while the undesirable operators share a Prioritization Threshold.

Another complication in this example is that Operator H (ANSI-136) has purchased certain areas from Operator C. Furthermore, Operator C may be selling more of its areas to Operator H in the future. Assume that it was agreed that Operator H would broadcast Operator C's SOC as an alternative SOC so that existing customers (from Operator C) in these areas can still recognize the system without reprogramming the system selection databases 12C of the mobile stations 10.

To accommodate the foregoing complex scenario, the Precedence fields may be set to allow the undesirable SOCs to override any other SOCs to determine the "true" Prioritization Threshold. Therefore, any system broadcasting an undesirable SOC will not have its Prioritization Threshold determined by another SOC (except Home) that is broadcast on this system. However, a SID can override the SOC to allow specific areas to be taken into account.

Fig. 15 illustrates the resulting System Identification Parameter lists, while Fig. 16 illustrates the resulting Special Parameter Settings.

Furthermore, assume that Operator A desires the mobile station 10 to select Non-Public systems over all other systems (even an Operator A system). This requirement can be satisfied by assigning Non-Public systems a Prioritization threshold that is higher than all others that are assigned. Additionally, the precedence for Non-Public systems is set so that the PSID/RSID overrides any other parameters that are broadcast to identify the system.

In this case the Functionality Thresholds are set as follows: Usability Threshold = 50; Background Scanning Prevention Threshold = 95 (this setting allows a transition from Operator C to a more preferred operator in areas 1 and 7; and Immediate Usage Threshold = 95 (this setting is possible because Operator A and Operator B are never present in the same area). To allow the mobile station to utilize GSM and ANSI-136 the Protocol Utilization field is set to allow usage of both protocols.

Further, assume for this example that Operator A is highly promoting its GPRS capability. In addition, Operator A is charging an additional fee for using GPRS services. Operator C does not have GPRS services, but plans to implement them in the future. However, Operator D does have GPRS services in some areas. The fee that Operator A charges for the GPRS service is more than enough to compensate for the difference in roaming agreements between Operator C and Operator D. Therefore, Operator A will profit more

when its customers use GPRS on Operator D than when its customers use Operator C without GPRS. Therefore, it is beneficial for Operator A to have its mobile stations 10 select Operator D over Operator C only when GPRS is available. However, no other operator priorities should be affected by the GPRS service offering.

This scenario can be accommodated by setting the value for the Attribute Modifier for GPRS. This value must be greater than the difference between the Prioritization Thresholds for Operators C and D. This value must also be less than the difference between the Prioritization Thresholds of any other adjacent (according to prioritization) operators. An Attribute modifier for GPRS with a value of 7 will provide this function. The specific priority of an Operator D system with GPRS is 87, while the specific priority of an Operator C system without GPRS is 85. In this case, the Operator D system has the higher priority. Furthermore, the difference in Prioritization Thresholds between all other adjacent (according to prioritization) operators is 10 or greater. Therefore, the GPRS service offering will not affect their prioritization.

Based on the foregoing example, it can be appreciated that this invention provides a novel and improved multi-protocol system selection capability for the mobile station 10. Furthermore, and as was discussed above in regards to the prior art system selection algorithms, the system selection requirements, criteria and algorithms are continually evolving. As the multiple protocol capability of mobile stations and system operators becomes more established, it is expected that this evolution to continue. Therefore, there is a strong need for a flexible algorithm that can adapt to the changing market requirements without major revisions in standards, mobile station software, and network software. A presently preferred embodiment of an advanced multi-protocol system selection algorithm that is capable of meeting these needs has thus been provided above. The advanced multi-protocol system selection algorithm provides a number of benefits, including the following:

(A) A variable number of priority groups can be established to provide additional flexibility in system prioritization. This allows the prioritization to resemble more closely the actual desirability of the roaming agreements between network operators. This capability saves the operator from having to force the true priorities into a static priority set. Therefore, the operator does not have to prioritize based on the most common operator configurations within an area, and then attempt to use additional data to consider the special cases.

Furthermore this capability can greatly reduce the number of SIDs required to be stored in the database 12C due to the reduction of the special case areas.

(B) The multi-protocol system selection algorithm described above also provides a fully configurable method for determining system priority when multiple identification parameters are broadcast on a single system.

(C) The multi-protocol system selection algorithm described above also provides a method for using the attributes of a system (for example, GPRS support) to influence system selection, while still using system identification prioritization (as in Intelligent Roaming).

(D) The multi-protocol system selection algorithm described above also provides a high level of operator configurability, which reduces the likelihood of standards and software changes as the system selection requirements evolve over time.

Although described in the context of various database fields, system features, signaling protocols and the like, it should be appreciated that these are exemplary, and should not be construed in a limiting sense upon the practice of these teachings.

Thus, while the invention has been particularly shown and described with respect to preferred embodiments thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the scope and spirit of the invention.

CLAIMS

What is claimed is:

1. A method for controlling the operation of a mobile station, comprising steps of:

assigning priority values to individual ones of a plurality of wireless systems;

inputting data into a database that is stored within a memory of the mobile station, the inputted data representing at least one list, the at least one list storing descriptor information specifying identities and assigned priority values of the plurality of wireless systems; and

controlling at least one of a scanning behavior or a camping behavior of the mobile station in accordance with the assigned priority values and a plurality of priority thresholds.

2. A method as in claim 1, wherein said plurality of priority thresholds define a plurality of priority ranges, and wherein the step of controlling includes a step of comparing a priority value for one of the wireless systems to the plurality of priority thresholds to determine what priority range the wireless system falls within.

3. A method as in claim 1, and further comprising a step of modifying an assigned priority value as a function of a features capability of the associated one of the plurality of wireless systems.

4. A method as in claim 1, wherein the descriptor information is comprised of a system identification (SID) identifier.

5. A method as in claim 1, wherein the descriptor information is comprised of a system operator code (SOC) identifier.

6. A method as in claim 1, wherein the descriptor information is comprised of a public land mobile network (PLMN) identifier.

7. A method as in claim 1, wherein said plurality of wireless systems comprise at least two wireless systems having different air interface protocols.

8. A method as in claim 7, wherein one of the at least two wireless systems is one of a GSM wireless system, an ANSI-136 wireless system, or an AMPS wireless system.

9. A method as in claim 1, wherein said plurality of wireless systems comprise at least two wireless systems that operate in different frequency bands.

10. A method as in claim 9, wherein one of the at least two wireless systems is one of a GSM wireless system, an ANSI-136 wireless system, or an AMPS wireless system.

11. A method for controlling the operation of a mobile station, comprising steps of:

assigning priority values to individual ones of a plurality of wireless systems appearing in at least one list;

inputting data into a database that is stored within a memory of the mobile station, the inputted data representing the least one list, the at least one list also storing descriptor information specifying identities of the plurality of wireless systems;

modifying an assigned priority value of at least one wireless system as a function of a features capability of the wireless system; and

controlling at least one of a scanning behavior or a camping behavior of the mobile station in accordance with the priority values and a plurality of priority thresholds.

12. A method as in claim 11, wherein said plurality of priority thresholds define a plurality of priority ranges, and wherein the step of controlling includes a step of comparing a priority value for one of the wireless systems to the plurality of priority thresholds to determine what priority range the wireless system falls within.

13. A method as in claim 11, wherein the descriptor information of a particular list is comprised of at least one of a system identification (SID) identifier, a system operator code (SOC) identifier, or a public land mobile network (PLMN) identifier.

14. A method as in claim 11, wherein said plurality of wireless systems comprise at least two wireless systems that operate with at least one of different air interface protocols or in different frequency bands.

15. A method as in claim 14, wherein one of the at least two wireless systems is one of a GSM wireless system, an ANSI-136 wireless system, or an AMPS wireless system.

16. A mobile station, comprising:

a controller;

a wireless transceiver for conducting bidirectional communications with a wireless system; and

a memory storing a database comprised of data representing at least one list, the at least one list storing descriptor information specifying identities of a plurality of wireless systems and priority values for individual ones of the plurality of wireless systems; wherein

said controller is responsive to a receipt of features capability information from a wireless system, via said transceiver, for selectively modifying an assigned priority value of the wireless system as a function of a features capability information and for controlling at least one of a scanning behavior or a camping behavior of the mobile station in accordance with the priority values and a plurality of priority thresholds.

17. A mobile station as in claim 16, wherein said plurality of priority thresholds define a plurality of priority ranges, and wherein said controller compares a priority value for one of the wireless systems to the plurality of priority thresholds to determine what priority range the wireless system falls within.

18. A mobile station as in claim 16, wherein the descriptor information of a particular list is comprised of at least one of a system identification (SID) identifier, a system operator code (SOC) identifier, or a public land mobile network (PLMN) identifier.

19. A mobile station as in claim 16, wherein said plurality of wireless systems comprise at least two wireless systems that operate with at least one of different air interface protocols or in different frequency bands.

20. A mobile station as in claim 19, wherein one of the at least two wireless systems is one of a GSM wireless system, an ANSI-136 wireless system, or an AMPS wireless system.

21. A mobile station as in claim 16, wherein said plurality of priority thresholds comprise a Forbidden Threshold, a Neutral Threshold, a Favored Threshold, a Partner Threshold, and a Home Threshold.

22. A mobile station, comprising:

a controller;

a wireless transceiver for conducting bidirectional communications with a wireless system; and

a memory storing a database comprised of data representing at least one list, the at least one list storing descriptor information specifying identities of a plurality of wireless systems and network operator assigned priority values for individual ones of the plurality of wireless systems; wherein

said controller is operable for controlling at least one of a scanning behavior or a camping behavior of the mobile station in accordance with the priority values and a plurality of priority thresholds.

23. A mobile station, comprising:

a controller;

a wireless transceiver for conducting bidirectional communications with a wireless system; and

a memory storing a database comprised of data representing at least one list, the at least one list storing descriptor information specifying identities of a plurality of wireless systems and network assigned priority values for individual ones of the plurality of wireless systems; wherein

said controller is operable for modifying an assigned priority value of at least one wireless system as a function of a features capability of the wireless system and for controlling at least one of a scanning behavior or a camping behavior of the mobile station in accordance with the priority values and a plurality of priority thresholds.

24. A method for operating a wireless communications system, comprising steps of:

defining, by a system operator, a number of different wireless system priority classes and assigning, by the system operator, a plurality of Functionality Threshold values for a plurality of wireless systems;

downloading data into a database stored within a memory of a mobile station, the

downloaded data comprising the plurality of Functionality Threshold values; and

controlling wireless system selection operation of the mobile station in accordance with the downloaded data.

25. A method as in claim 24, and further comprising a step of modifying at least a portion of the downloaded data in accordance with a features capability of an associated one of the plurality of wireless systems.

Priority	Example 1	Example 2
1	Home PLMN	Home PLMN
2	Last PLMN	Home SID
3	Preferred PLMN	Last PLMN
4	Other PLMN	Preferred PLMN
5	Home SID	Positive SID
6	Positive SID	Other PLMN
7	Other SID	Other SID

FIG. 1
(PRIOR ART)

Group	GSM	ANSI-136
A	Home	Home Partner
B	Preferred Neutral	Favored* Neutral
C	Forbidden	Forbidden

FIG. 2
(PRIOR ART)

Group	ANSI-136 Preferred	GSM Preferred
A	ANSI-136 Home ANSI-136 Partner GSM Home	GSM Home ANSI-136 Home ANSI-136 Partner
B	ANSI-136 Favored* GSM Preferred ANSI-136 Neutral GSM Neutral	GSM Preferred ANSI-136 Favored* GSM Neutral ANSI-136 Neutral
C	ANSI-136 Forbidden GSM Forbidden	GSM Forbidden ANSI-136 Forbidden

FIG. 3
(PRIOR ART)

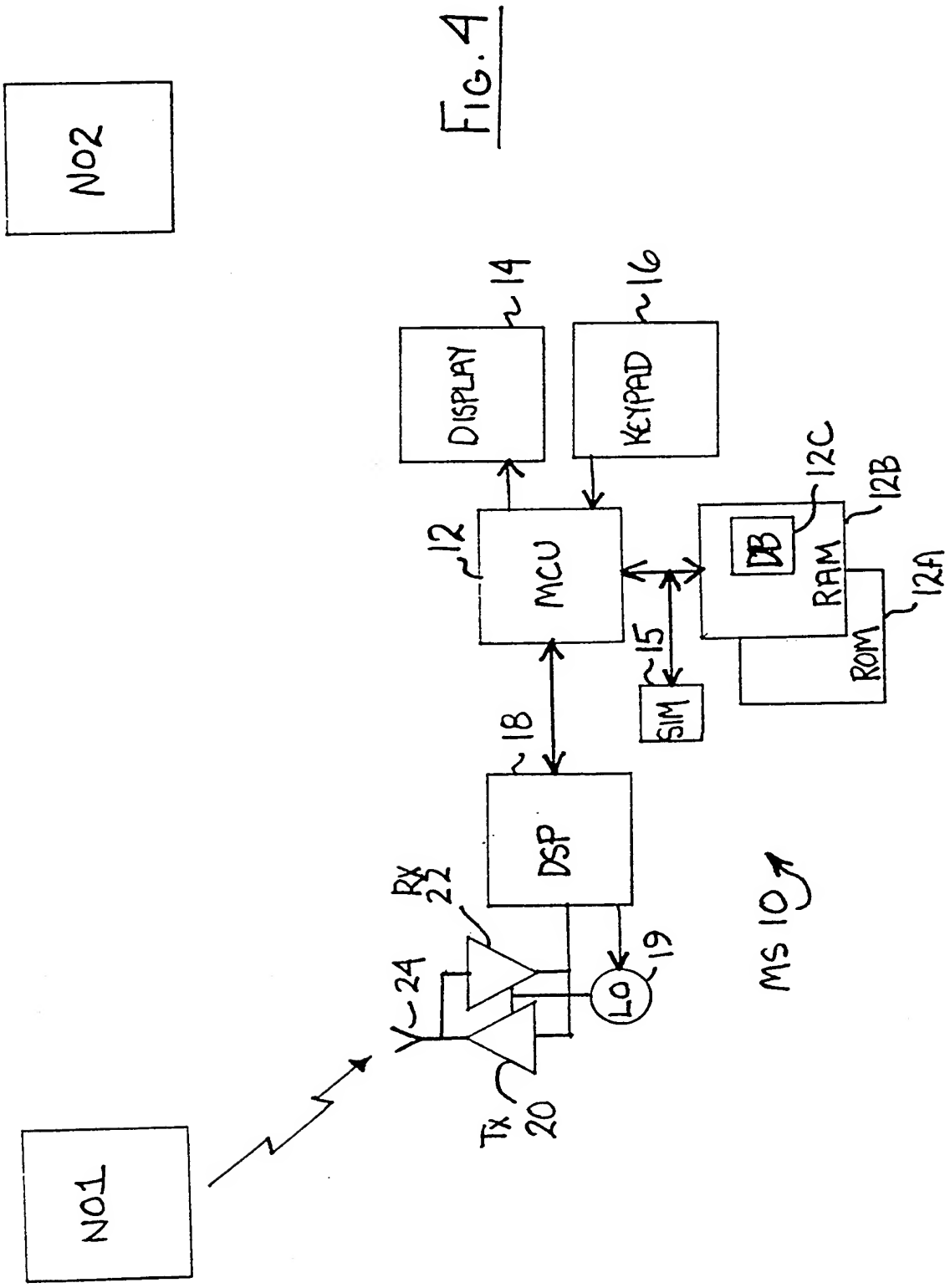
NO2
DISPLAY
14
KEYPAD
16
12
MCU
12C
DB
12B
RAM
12A
ROM
15
SIM
18
DSP
RX
22
24
19
LO
Tx
20
NO1
MS 10

FIG. 4

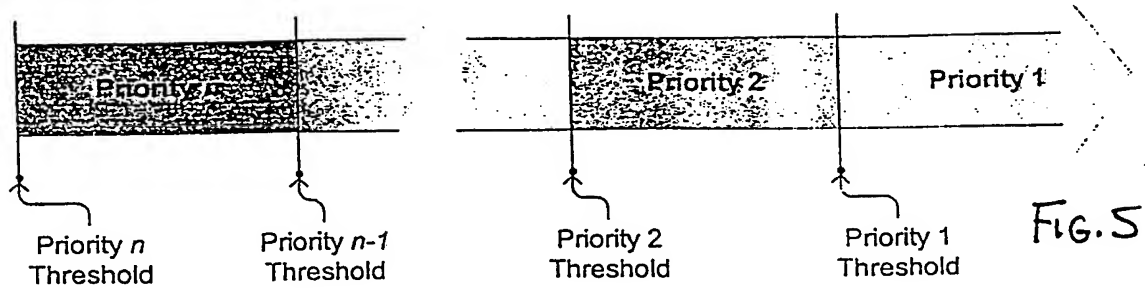

FIG. 5

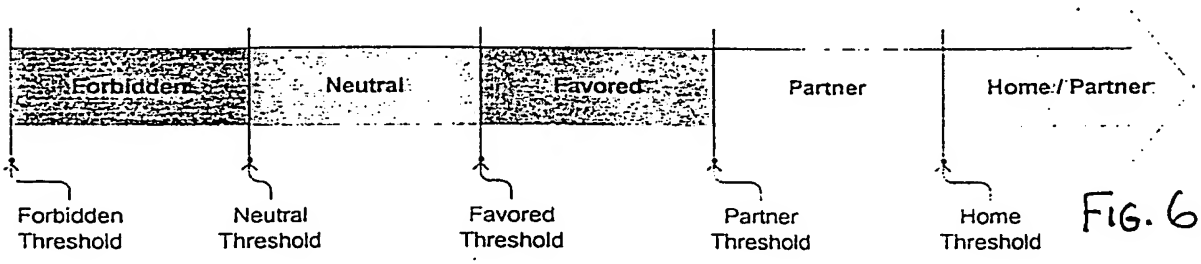

FIG. 6

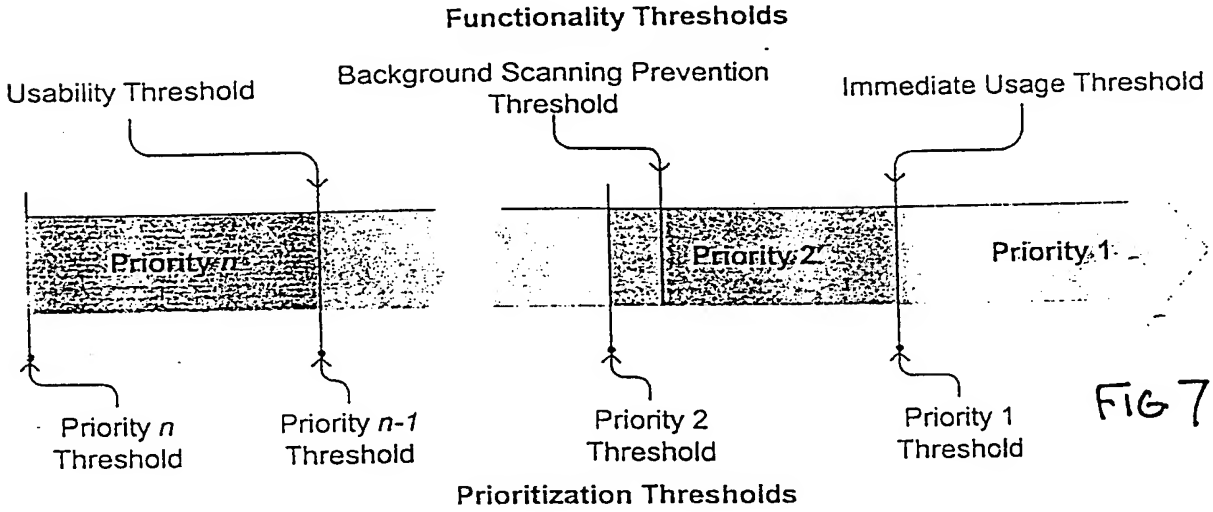

FIG 7

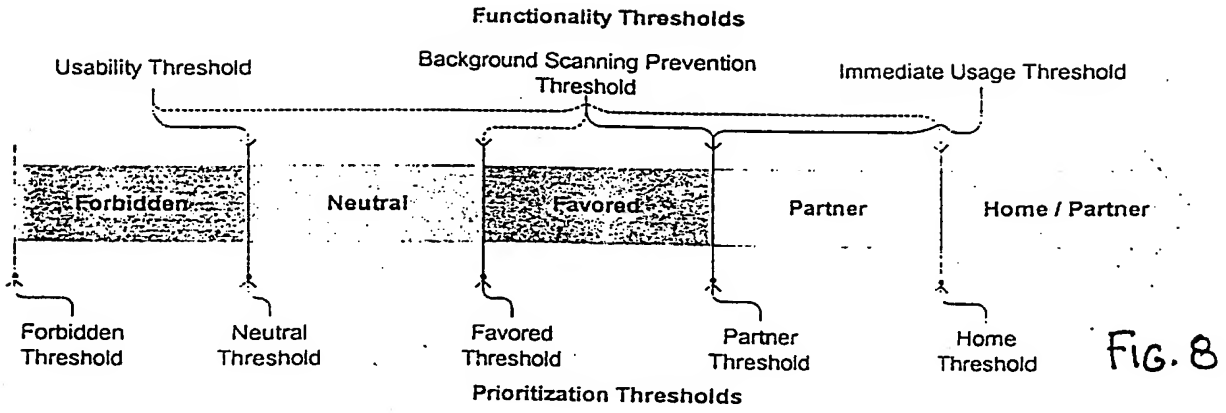

FIG. 8

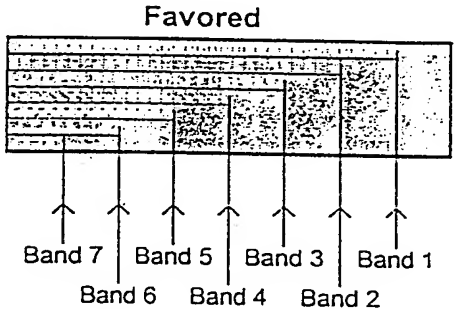

FIG. 9

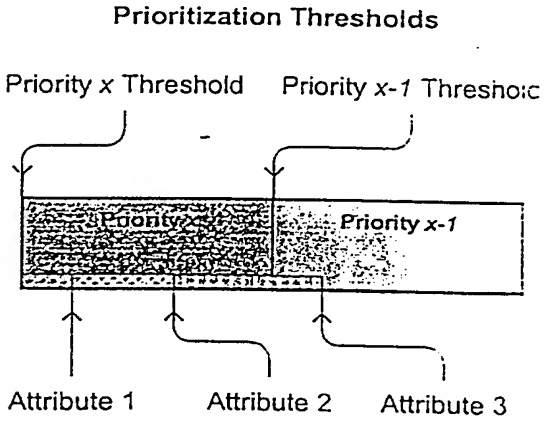

FIG. 10

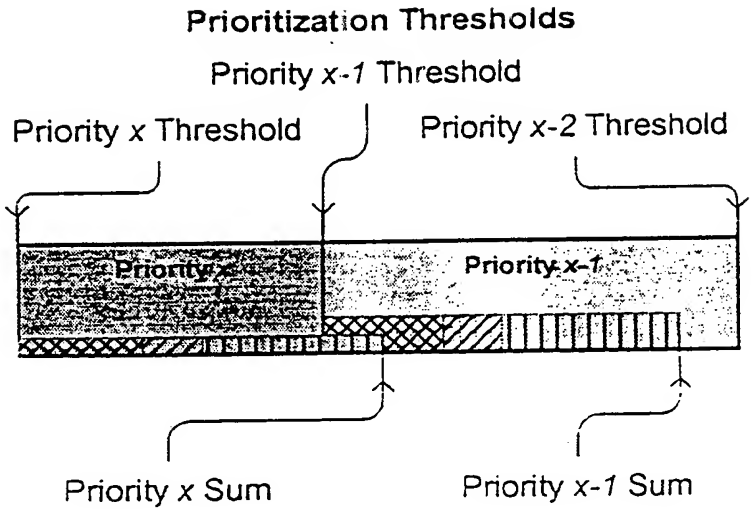

FIG. 11

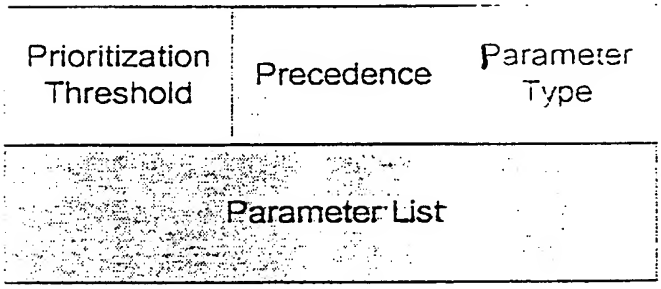

FIG. 12

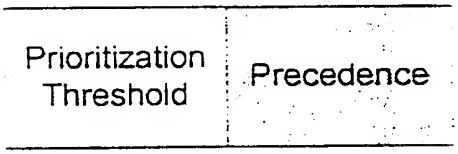

FIG. 13

Area	Operator				
	A	B	C	D	E
1	✔		✔		
2	✔			✔	
3	✔				✔
4			✔		✔
5				✔	✔
6			✔	✔	✔
7		✔	✔		
8		✔		✔	

FIG. 14

Prioritization Threshold	Precedence	Parameter Type	List Contents
95	60	PLMN	Operator B PLNM List
85	59	SID	Operator C SID List
85	50	SOC	Operator C SOC List
80	58	PLMN	Operator D PLMN List
70	57	SID	Operator E SID List
70	49	SOC	Operator E SOC List
0	54	PLMN	Operators F and G PLMN List
0	90	SID	Operators H and I SID List
0	51	SOC	Operators H and I SOC List

FIG. 15

Special Category	Prioritization Threshold	Precedence
Home	105	100
Unmatched SID	50	0
Unmatched SOC	50	0
Unmatched PLMN	50	0
Non-Public	115	100

FIG. 16

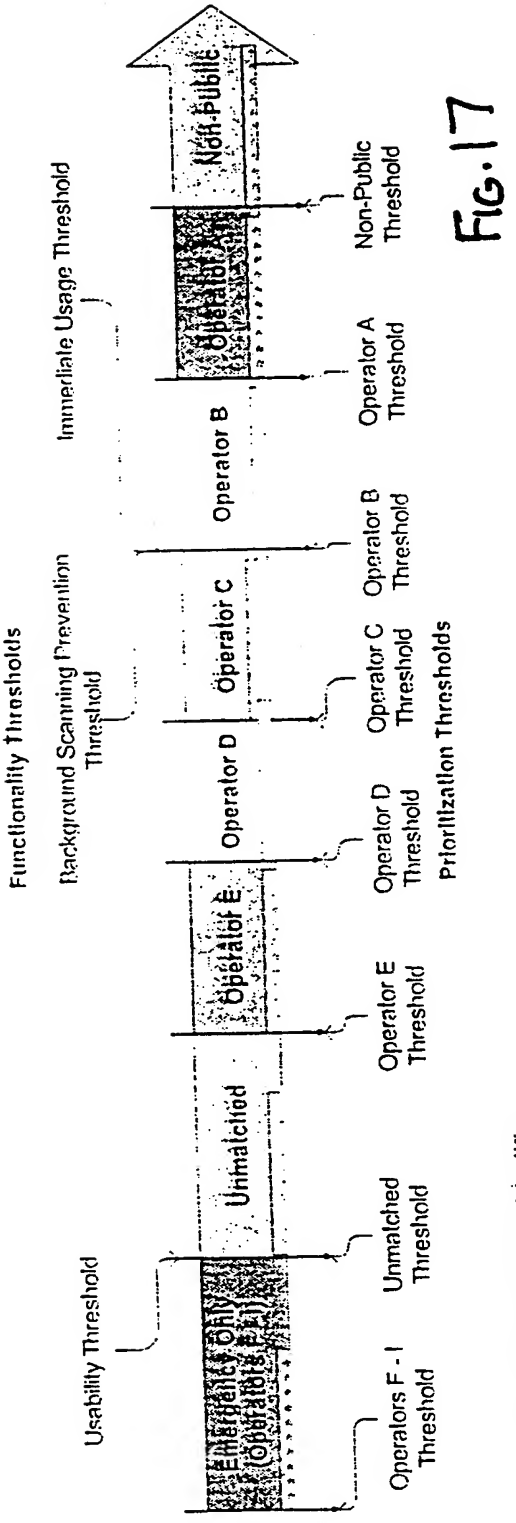
Functionality Thresholds
Usability Threshold
Background Scanning Prevention Threshold
Immediate Usage Threshold
Emergency Only
Unmatched
Operator E
Operator D
Operator C
Operator B
Operator A
Non-Public
Operators F - I Threshold
Unmatched Threshold
Operator E Threshold
Operator D Threshold
Operator C Threshold
Operator B Threshold
Operator A Threshold
Non-Public Threshold
Prioritization Thresholds
GPRS Modifier

FIG. 17